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Load Bearing Capacity Tests of Mechanical Joining on Timber-concrete Beam

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Abstract

Timber-concrete composite structures, which use advantages of both materials, are suitable for new works and reconstructions of civil and residential buildings. There are described many methods of joining between timber beam and concrete slab in technical literature. Joints are more and more sophisticated which brings higher demands on work control and technology. Main goal of the paper is in design technologically low demanding method of joining with steel plates and nails, to test its shear strength and to compare it with other similar joining methods.

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Keywords: Timber, concrete, composite, joining, nail;

1. Introduction

Main goal of this paper is to check up possibilities of timber – concrete beam joints using thin plates, which are nailed up to timber beam by convex nails.

The chosen joints have to fulfill two conditions. The joint elements have to be readily available and their assembly should not be difficult as other means of joining (glued thin plinth, milled gaps ect.). In many practical cases simple joining between timber and concrete was considered as more effective than other sophisticated methods [1], [5].

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This mean of joining should be suitable for reconstructions, where it is impossible to remove the timber elements for repairs in workshop. Using convex nails seems to be useful because of frequent dynamical load (ceiling vibration) [6].

The results of thin plate and nails joining tests were compared with results of similar joints. The steel thin plates and nails were compared to gang nails [2].

2. Experimental research

The six laboratory samples were made for shear load bearing capacity tests. The half of samples were made with 2 *mm* thick thin plate and convex nails of 4 mm in diameter (B samples). Another three samples were made with the gang-nail joints (T samples). The dimensions of the laboratory samples are stated in Fig. 1.

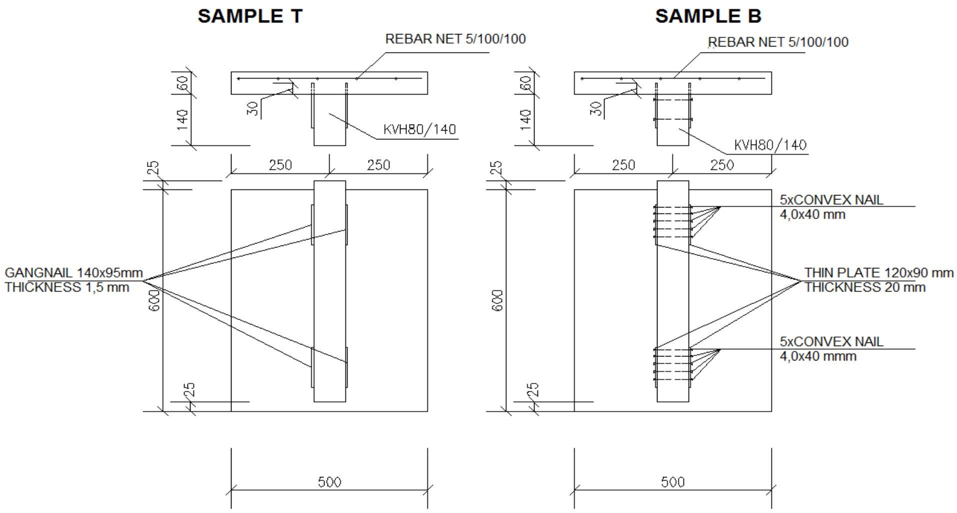

Fig. 1. Dimensions of laboratory samples

There was used concrete C 20/25 and rebar net with steel grade 10 505 (rebar ∅ 5 *mm*, raster 100/100 *mm*) for manufacturing samples. The timber beams are made of spruce planed timber type KVH of C24 class and 12% moisture.

Load bearing capacity was tested at EU 40 press in laboratory of Faculty of Civil engineering Technical University Ostrava (loading proceed with constant speed of press). Shear loading was performed with help of mounting bracket, which made sample stable against turn over by eccentric load action Fig. 2.

Fig. 2. Mounting bracket

3. Test results

The T samples performed higher shear load bearing capacity than samples with the thin plate and convex nails.

When the load force was 36 *kN* (60 % of maximum load bearing capacity) a small crack appeared in the timber beam, right at the end of gang nail plates. Rise of the crack is also visible at the graph of force to deformation relation Fig. 3.

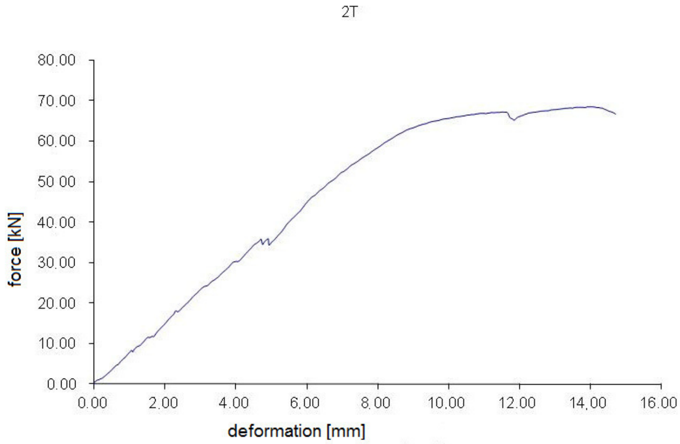

Fig. 3. Force to deformation relation

Final failure of the joint appeared in gang nail plate, which showed up the shear slope Fig. 4. Graph Fig. 3. describing loading process has almost linear shape similar to stress-strain diagram of steel. The failure appeared after excess of shear load bearing capacity of the steel plates by load force 61.3 kN.

There was no observation of concrete failure. Except for the first crack, there was no failure in timber part, too.

Fig. 4. Slope of gang nail

Test process on the samples with thin plate (thickness 2 *mm*) and convex nails (4 *mm* in diameter) is displayed on the graph in Fig. 6.

There was found a different type of failure than in the previous case. Thus, the failure diagram has different shape.

The thin plates stayed unharmed, but the nails deformation is obvious. Shift of plates to timber beam is evident even on the photo in Fig. 5, where lighter layer of wood is visible, which was originally covered by thin plate. Thin plates and concrete show no failure.

Fig. 5. Shape of thin plate

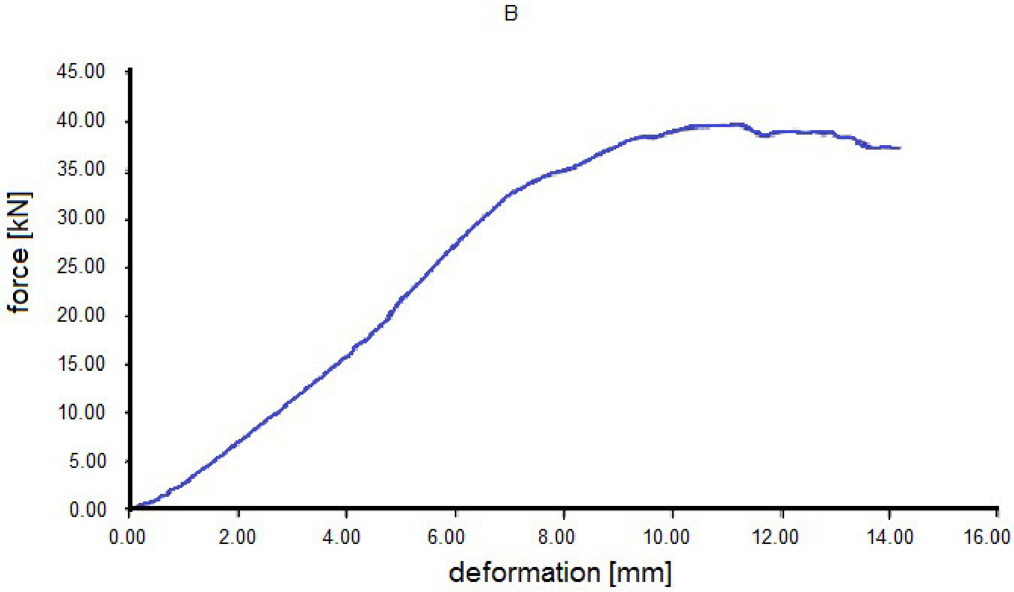

Fig. 6. Deformation graph of B sample

The load bearing capacity of four thin plates was calculated by relation below:

$$F_{v,d} = n\frac{0,6.f_{u,k}.t.(b-4.R)}{\gamma_{M,2}} = 4\cdot\frac{0.6\cdot 500\cdot 0.002\cdot(0.12-0.02)}{1.25} = 192.0kN \tag{1}$$

The shear load bearing capacity of joints (timber/thin plate) of group of 20 convex nails is much lower, it is $F_{v,d}$ = 21.35 *kN* (calculation in Fig. 7.) [4]. The design load bearing capacity in local compression of concrete is $F_{v,d}$ = 42.03 *kN* [3]. The weakest element of the joint in this example is the group of nails, which was verified by the tests.

Table 1. Calculation of shear strength of group of 20 nails

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Input values		**Calculated values**		**Loadbearing capacity of joint**			
d [mm]	4	$F_{h,1,k}$ [N.mm^{-2}]	22.8288			**a) [kN]**	**Total result**
$F_{u,k}$ [N.mm^{-2}]	380	$M_{y,r,k}$ [kN.m]	0.066414			1.07	
α [deg]	0	k_{90}	1.36	$F_{v,R,k}$=	min		**21.35 kN**
α [rad]	0	n (pcs.)					
ρ [kg.m^{-3}]	290					**b) [kN]**	
t_1 [mm]	38					6.16	

4. Conclusion

According to test results the calculated force in failure of the B sample is correct. The sample B had lower shear load bearing capacity than sample T. This fact was caused by low number of nails in the joint. To make the joint more rigid, it is possible to increase the amount of nails or the amount of steel plates.

Variability in number of nails seems to be advantage against using gang-nails. It alowes to suit the joints to requirements of composite construction.

The elements of composite timber concrete beam (wood and concrete at least) and resulting composite beam have big scale of mechanical characteristics. This is the reason, why the probabilistic design and analysis look perspective [7], [8].

Next research focus on the joint with thin plate and convex nails should be magde on beams with real dimensions beams. The cyclic load testing seems to be useful for these type of composites, too.

Acknowledgement

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